

# Masses and magnetic moments of heavy flavour baryons in hyper central model

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**Abstract.** we employ the hyper central approach to study the masses and magnetic moments of the baryons constituting single charm and beauty quark. The confinement potential is assumed in the hyper central co-ordinates of the coulomb plus power potential form.

## 1. Introduction

Recently, there is a renewed interest in the magnetic moments and spectroscopy of heavy flavour baryons both experimentally and theoretically [1, 2, 3, 4, 5, 6]. Many of the constituent quark models have provided the masses of baryons and their magnetic moments correctly at the light flavour sector. However many of these models do not provide the form factors correctly that reproduces experimental data [1] and for this reason alternate schemes to describe the properties of baryons particularly in the heavy flavour sector are being attempted [1]. It should be mentioned that, hyper central potential contains the effects of the three body force as it is suggested by lattice QCD calculations [5]. For the low-lying resonance states it is good approximation to simply take the space wave functions of the hyper Coulomb potential instead of the ones coming from the numerical solution of the linear plus Coulomb potentials with hyperfine interaction. We computed the masses of the charmed and beauty baryons under this scheme for different power indices starting from 0.5 to 2.0. The magnetic moments of heavy flavour baryons are computed based on the nonrelativistic quark model using the spin-flavour wave functions of the constituting quarks and their effective masses within the baryon.

## 2. The Model

The model Hamiltonian for the baryon is expressed in terms of the Jacobin co-ordinates  $(\rho, \lambda)$  as well as hyper central co-ordinates  $(x)$  as be written as

$$H = \frac{P_\rho^2}{2m_\rho} + \frac{P_\lambda^2}{2m_\lambda} + V(\rho, \lambda) = \frac{P_x^2}{2m} + V(x) \quad (1)$$

For the present study we considered the hyper central potential as,  $V(x) = -\frac{\tau}{x} + \beta[7].x^\nu + \kappa + V_{spin}(x)$ . The baryon masses are computed as  $M_B = \sum_i m_i + \langle H \rangle = \sum_i m_i^{eff}$ . The magnetic

**Table 1.** Masses of charm and beauty baryons in MeV

Baryon	Potential index $\nu$					[9]	[8]	[10]
	0.5	0.7	1.0	1.5	2.0			
$\Sigma_c^{++}$	2550	2473	2443	2436	2436	$2460 \pm 80$	$2454 \pm 0.18$	—
$\Sigma_c^{*++}$	2618	2538	2506	2499	2498	$2440 \pm 70$	$2518.4 \pm 0.6$	—
$\Sigma_b^+$	5871	5812	5787	5780	5780	$5770 \pm 70$	—	$5808_{-2.3}^{+0.2} \pm 1.7$
$\Sigma_b^{*+}$	5808	5837	5810	5802	5802	$5780 \pm 70$	—	$5829_{-1.8}^{+1.6} \pm 1.7$

**Table 2.** Magnetic moments of charm and beauty baryons in terms of Nuclear magneton  $\mu_N$ 

Baryon	Potential index $\nu$					RQM[3]	NRQM[3]
	0.5	0.7	1.0	1.5	2.0		
$\Sigma_c^{++}$	1.8809	1.9394	1.9635	1.9688	1.9692	1.760	1.860
$\Sigma_c^{*++}$	3.2806	3.3837	3.4272	3.4373	3.4379	—	—
$\Sigma_b^+$	2.1995	2.2216	2.2314	2.2339	2.2341	2.070	2.010
$\Sigma_b^{*+}$	3.2806	3.3837	3.4272	3.4373	3.4379	—	—

\*indicates  $J^P = \frac{3}{2}^+$  state.

moment of baryons are obtained in terms of its constituent quarks as  $\mu_B = \sum_i \langle \phi_{sf} | \mu_i \vec{\sigma}_i | \phi_{sf} \rangle$  where  $\mu_i = \frac{e_i}{2m_i} \mu_N$ . Here  $m_i$ ,  $e_i$  and  $\sigma_i$  represent the mass, charge and the spin of the quark constituting the baryonic state and  $|\phi_{sf}\rangle$  represents the spin-flavour wave function of the respective baryonic state. Our model parameters are  $m_c = 1394 MeV$ ,  $m_b = 4510 MeV$ ,  $m_u = 338 MeV$ ,  $b = 13.6$ ,  $\frac{\beta}{m\tau} = 1 (MeV)^\nu$ ,  $A = 140.7 MeV$  and  $\alpha = 850 MeV$ .

### 3. Result and Discussion

The computed masses and magnetic moments of the  $J = \frac{1}{2}^+$  and  $J = \frac{3}{2}^+$  states of the single charm and beauty flavour baryons are listed in Table 1 and 2. The masses and magnetic moments of the single heavy flavour baryons are found to be in accordance with other model predictions. It is important to see that the baryon mass do not change appreciably beyond the potential power index  $\nu > 1.0$  (See Table 1) and the magnetic moment predicted in our model do not vary appreciably with different choices of  $\nu$  running from 0.5 to 2.0 (See Table 2).

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